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ABSTRACT

This paper describes work aimed at catering the content of World Wide Web (WWW) pages to the needs of different users, including elderly people and users with vision and motor impairments. An overview is provided of the AVANTI system, a European WWW-based tourist information system that adapts Web pages to each user's individual needs before presenting them to the user. System components (i.e. multimedia databases, the user model server, the information resource control structure, a hyperstructure adapter, and a user interface) are summarized, and the sources of information that the system uses as the basis for its assumptions about the user are described. An example of adaptability in AVANTI is presented, and users' experiences are reported. (Contains 17 references.) (MES)

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Adapting Web Information to Disabled and Elderly Users

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Abstract: Substantial research and standardization efforts already exist to make it easier for people with physical impairments to perceive and interact with web pages. This paper describes work aimed at catering the *content* of web pages to the needs of different users, including elderly people and users with vision and motor impairments. The AVANTI system and related efforts in the AVANTI project will be discussed and experiences reported.

1. Introduction

The World Wide Web is currently the most frequently visited electronic resource and is likely to become the access ramp to the electronic information highway of the next millennium. Web access should therefore ideally be available to everyone in order not to create yet another informational, and hence economical and social, disparity in society. Special efforts must be put into making the access to the web available to those who so far have been at a disadvantage, including people with disabilities and elderly people who until recently were only minority users of information technology. The terms "Design for All" and "Universal Access" have been coined to denote a design methodology for computer interfaces that does not automatically preclude users with special needs from using the system, as it often used to be the case with software developed to date.

In this context, increasing efforts are currently being made to render the web accessible to users with sensoric deficiencies. This primarily includes users with visual impairments [WAI, BrailleNet, Morley et al. 1998] and to some extent also users with motor impairments [Hermsdorf 1998, Hermsdorf et al. 1998]. Adaptations that are being researched include alternate input and output modalities (e.g., speech instead of text), adjustable behavior of user interface elements (e.g., toolbars with rotating cursor), and abridged non-visual navigation within and across web pages.

However, making the interface and the interaction with the interface universally accessible does not yet render a web site fully accessible. Users do not only have different needs with respect to perception and interaction, but also with respect to the information that is conveyed through the web. Users with certain disabilities often have specific information needs that are not shared by other users (e.g., information on wheelchair accessibility for motor-impaired people). Likewise, they are not very interested in certain information that may be important to other users (e.g., information about musical events for deaf users).

The amount of additional or different information required by certain user groups is sometimes quite sizeable. It would be a burden for all other users if this information were presented to everybody. This paper discusses principles to also apply a user-friendly design-for-all principle to the information that is being presented on the WWW, in addition to applying it to the interface and the interaction with the interface. The approach taken consists in the adaptation of the information to the individual information needs of each user, as expressed in a user model of each user. Research in the AVANTI project [Fink et al. 1999] will be described that developed the prototype of a comprehensive tourist information system for a wide range of users, including people with disabilities and elderly users.

2. Special Information Needs

In the area of tourism, a wide variety of different information needs can be observed. They stem from different interests, knowledge, preferences and physical abilities of each individual user. A user needs analysis that was carried out in the context of AVANTI revealed the following special information needs, among many others [Bini 1996].

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Mobility-impaired people require substantially more information than able-bodied users and any other disability group. (This information is mostly redundant for these other users and should be omitted when presenting information to them). For wheelchair-bound users, detailed information concerning the accessibility of buildings (e.g., the existence and the dimensions of ramps and elevators, the type and width of doors, the type of floor covering) is important and should therefore be automatically provided. They should also be warned unsolicitly when routes present insurmountable obstacles (like steps and slopes with a gradient of over 15% lengthwise and over 2% sideways) or when routes are very difficult to master (e.g., routes with a gradient between 8% and 15%, or routes with plenty of traffic).

For blind users, not only the modality of the presented information must be changed to tactile and/or audio output; in addition, supplementary orientation and navigation aids, like an additional table of content containing all internal and external links on a hypermedia page, are helpful [Kennel et al. 1996]. They should also be automatically warned of the presence of mobile obstacles, acoustic pollution, and long distances that need to be conquered without tactile or acoustic clues, since these are the main mobility barriers for this user group.

Elderly users are sometimes included in categories of serious handicap due to age and health conditions and should receive the respective special information. They should also be automatically warned of the presence of narrow or spiral staircases, slippery surfaces unaided by hand rails, and long distances that need to be conquered without rest or relief points. Escalators, elevators and restrooms should be particularly marked out.

The need for specialized information however does not only stem from disability needs. In any information system, the following distinctions between users should be made, among many others:

- Users who are interested in a specific subject area should automatically receive more detailed information on it than users who lack this interest.
- For computer novices, usage instructions should be augmented by an explanation. This is normally not necessary for experienced computer users.
- For users with low-bandwidth network access (e.g., via a slow modem), information with high data volume (e.g., videos and high-resolution pictures) should be replaced by less demanding, but nevertheless appropriate equivalents, in order to reduce download times. The response time of a hypermedia system is extremely critical from a usability point of view [Nielssen 1990].

In order to cater to these different information needs of users, techniques from the area of adaptive hypertext and hypermedia systems [Brusilovsky et al. 1998] have proven to be very useful. These systems dynamically generate hypermedia pages based on constantly updated assumptions about the user that are stored in a user model [Kobsa 1993].

3. Overview of the AVANTI System

AVANTI is a WWW-based tourist information system that adapts web pages to each user's individual needs before presenting them to the user. The system provides hypermedia information about a metropolitan area (e.g., about public services, transportation, buildings) for a variety of users (e.g., tourists, citizens, travel agency clerks, elderly people, blind persons, wheelchair-bound people, and users with slight forms of dystrophy[1]) with different interests, knowledge, and abilities. The system can be accessed from people's homes, from travel agencies, public information kiosks and on the go. Users' hardware platforms, software environments, network speeds, and environmental surroundings thus vary widely. In order to cater to the different user needs and usage environments, AVANTI exploits methods and tools developed in the context of adaptive and adaptable systems [Oppermann 1994], user modeling [Kobsa 1993] and adaptive hypertext and hypermedia systems [Brusilovsky et al. 1998].

AVANTI consists of the following main components:

- Multimedia Databases with information about the AVANTI domain in different modalities (mostly text, images, and videos). They also include a restricted data model.
- The User Model Server which hosts models of all users. These models primarily contain information about users' abilities and to some extent assumptions about their interests.
- The Information Resource Control Structure (IRCS), a repository of mostly generic web pages that include links to database entries and rules for user-adaptation based on the current user model. IRCS pages are encoded in an extension to HTML.

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[1] Dystrophy is a range of circa 40 neuromuscular diseases resulting in muscle weakness, paralysis, cramps, impaired muscle relaxation, etc.

- A Hyperstructure Adapter that generates user-adapted hypermedia document descriptions on the basis of the IRCS and the current user model.
- A User Interface that presents these hypermedia pages and performs necessary adaptations on the level of the user interface, particularly concerning the selection of appropriate modalities and interaction forms.

AVANTI acquires assumptions about the user based on the following sources of information:

- A short *initial interview* allows for the acquisition of primary assumptions [Pohl et al. 1995] about the user and is therefore a valuable source of information for initially assigning the user to certain user subgroups (see the "stereotypes" below).
- Basic information about users' disabilities can be stored on a contactless *smartcard* that can be read from a distance of about 40-80 cm (15-30"), depending on the electromagnetic surroundings. Such a smartcard can record, e.g., information about users' visual and manual disabilities, so that AVANTI can adapt the modality of and the interaction with the interface while the user is approaching the system. Fig. 1 shows an example: here the fact that the current user is mildly vision-impaired is stored on the smartcard and read with the antenna around the monitor. This information then automatically leads to screen magnification.
- Based on primary assumptions about the user and additional information about the application domain, the system can draw *inferences* in order to acquire further assumptions about the user. For instance, if the user requests more than once detailed information on the history of some churches, he/she can be assumed to be interested in churches, and this detailed information will henceforth be automatically provided.
- *Stereotypes* [Rich 1979] contain assumptions about interesting characteristics of user subgroups (e.g., the presumable knowledge of domain experts or the presumable interests of wheelchair-bound users). If certain preconditions are met, a stereotype can be activated for a specific user, which means that the assumptions contained in the stereotype become assigned to the user.

Figure 1: Automatic screen magnification for a mildly vision-impaired user after reading the user profile on the smartcard from a distance

4. An Example of Adabtability in AVANTI

The web page depicted in Fig. 2 informs about the services, facilities and amenities that are available in "jolly hotel excelsior" in Siena, Italy. The page can be separated into three areas. The left column with the brick-pattern background contains mostly the main menu. The central area contains the "real" information (e.g., the services offered by a hotel), and the right column includes menu buttons that point to other relevant information.

In its present form, the page is tailored to a user who is experienced in using both computers and the AVANTI system and needs special information for wheelchair-bound and dystrophic people (information about these needs would come from an initial questionnaire or a contactless smartcard). For instance, the optional navigation path displayed in the upper left corner is only available to experienced web users since its usage requires at least a coarse mental model of the hypermedia space at hand. This path is therefore left out for web novices and their navigation tools restricted to the hierarchical Siena menu on the left-hand side since such users may be confused by alternative navigation elements on a hypermedia page. The hand icon pointing to "restaurants" and the link "nearest restaurants" in the lower right corner are pointing to information that is presumably interesting for the current user. Such an assumption is acquired by the system through inference mechanisms based on the navigation history. For instance, if the user requests more than once detailed information on the cooking style of some restaurant, she/he can be assumed to be interested in restaurants.

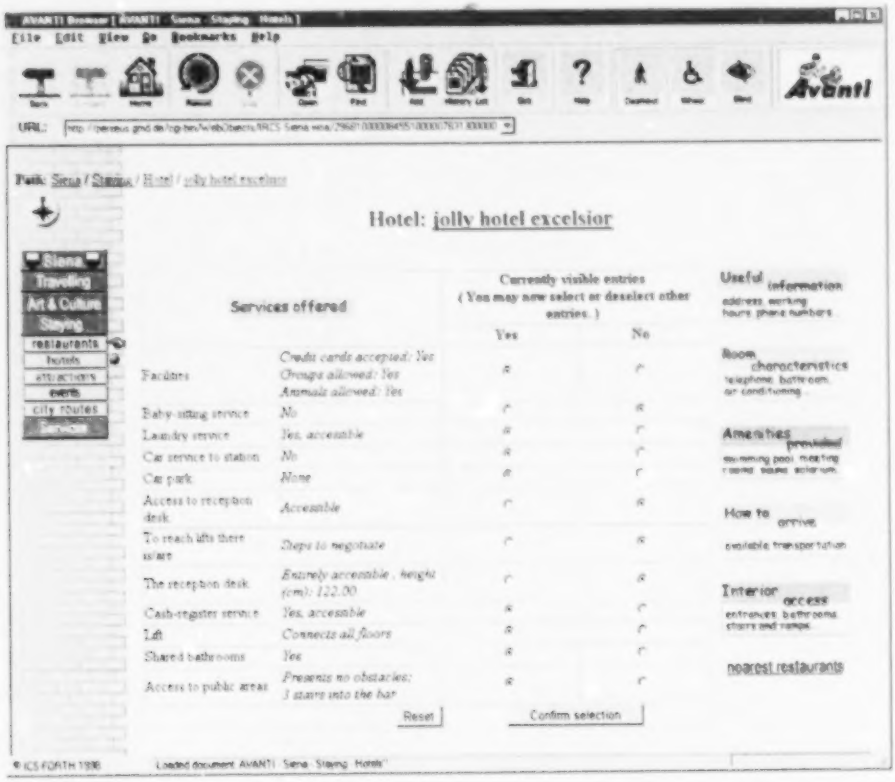

Figure 2: Example of Adaptive and Adaptable Elements in an AVANTI web page

Other optional elements are the so-called *role-taking buttons* in the toolbar of the AVANTI browser. The upper right corner contains the role-taking buttons "Deambul" for deambulation (walking around), "Wheel" for wheelchair, and "Blind"[2]. The availability of these buttons is also contingent on the AVANTI expertise of the user. If one or more of these buttons are pressed (e.g., "Deambul" and "Wheel" in Fig. 2), the user automatically obtains additional information for the selected user groups (e.g., additional information for dystrophic people with difficulties walking around and wheelchair-bound persons, respectively). These buttons were designed for people

[2] These buttons, as well as the "Exit" and "Help" buttons, are part of the page descriptions coming from the HSA. They are included in the AVANTI browser while its HTML parser is processing the page. Since the HSA behaves like a "normal" web server, it is also possible to access the HSA with any commercial browser. The extra buttons will then remain in the HTML page.

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who look for information on behalf of disabled persons. For instance, travel agency clerks can "take the role" of a wheelchair-bound customer while working with the AVANTI system. From a technical point of view, the role-taking buttons can be used to activate or deactivate certain stereotypes (i.e., "Dystrophic User", "Wheelchair User" and "Blind User").

In AVANTI, tables presented to the user contain those attributes only which the system deems to be relevant for him/her according to the current user model. The user is able to modify the system-initiated attribute selection by requesting an adaptable version of the table that includes all available attributes. Fig. 2 shows such an adaptable version where the user has de-selected "Baby-sitting service" and some other attributes and subsequently confirms his/her de-selection.

5. Experiences with AVANTI

The AVANTI system has been subject to extensive summative evaluations at three different cities in three different scenarios with a total of 180 subjects [AVANTI CD-ROM, Andreadis et al. 1998]. Users were tourists, business travelers, citizens, travel agency clerks, and users with vision and motor impairments. The common question shared by all experiments was whether the developed system is beneficial for users, and specifically whether it is technically feasible and useful for end users to introduce adaptability and adaptivity in the information content and user interfaces of hypermedia information systems.

Users were subject to usability tests to determine the system's learnability, efficiency of use and memorizability, users' error-proneness, satisfaction and overall attitude, and the specific contribution of adaptability and adaptivity. Data were collected through observation, interviews, questionnaires and the analysis of log files. The results allow one to conclude that AVANTI's adaptation features were generally well understood, used, and appreciated (some of them were not self-explanatory though) and that the benefit for information systems probably lies more in user satisfaction than in efficiency gain or error reduction.

A general finding was that experienced users are more inclined to take advantage of adaptability features than users with less experience. While adaptability features have been recognized and understood by most users, they have been more frequently used by AVANTI experts (namely adaptive tables), and computer and web experts (namely the path navigation tool). Travel agency clerks liked the possibility to create their own shortcuts.

Travel agents also appreciated very much the role-taking buttons. These buttons were generally well recognized, correctly understood, and frequently used.

Motion-impaired users were generally more satisfied with the information provided by the system and had a better attitude towards AVANTI than able-bodied users. They found the system properly designed for them and the information on accessibility very clear and useful for mobility. They also appreciated very much the level of detail reached by the system, and many of them praised the system enthusiastically. In contrast, able-bodied users did not easily find information for their purposes (and often this information was not present in the system). It also seems that their concept of mobility differs from that of impaired users in several ways, and was not properly reflected in the system.

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